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Abstract

Information technology is deeply penetrating into all walks of life. Through the acquisition of massive data, modeling and analysis in the information space, it has become an effective means to solve practical problems in the information society. At present, China is vigorously implementing black soil conservation projects. Aiming at the complex system protection engineering, it is necessary to rely on the strength of information technology to carry out problem modeling and algorithm solving in the process of black soil utilization and protection, and find the best protection way through simulation and emulation. Based on the analysis of the black land protection measures worldwide, the study puts forward the design idea of agricultural simulator based on the fifth paradigm from the perspective of intelligent technology, gives the organizational structure of the total factor agricultural simulator, and realizes the rapid operation and iteration of data flow through the intelligent OODA (observe, orient, decide, act) loop to continuously optimize the black soil protection technology. Finally, the study proposes the idea and framework of building agricultural simulator in the black land protection demonstration area, as well as the policy suggestions for the application and promotion of agricultural simulator in the process of black land protection.

Keywords

black land, emulator, the fifth paradigm, intelligent OODA loop

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Agricultural Simulator: Using Intelligent Technology to Get Data Flow for Black Land Protection

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Abstract: Information technology is deeply penetrating into all walks of life. Through the acquisition of massive data and the modeling and analysis in the information space, it has become an effective means to solve practical problems in the information society. At present, China is vigorously implementing black soil conservation projects. Aiming at the complex system protection engineering, it is necessary to rely on the strength of information technology to carry out problem modeling and algorithm solving in black soil utilization and protection, and find the best protection way through simulation and emulation. Based on the analysis of the black land protection measures worldwide, the study puts forward the design idea of agricultural simulator based on the fifth paradigm from the perspective of intelligent technology, gives the organizational structure of the total factor agricultural simulator, and realizes the rapid operation and iteration of data flow through the intelligent OODA (observe, orient, decide, act) loop to continuously optimize the black soil protection technology. Finally, the study proposes the idea and framework of building agricultural simulator in the black land protection demonstration area, as well as the policy suggestions for the application and promotion of agricultural simulator in black land protection. **DOI:** 10.16418/j.issn. 1000-3045.20210810001-en

Keywords: black land; emulator; the fifth paradigm; intelligent OODA loop

As a natural gift to mankind, black land provides the best soil for crop growth, and people even compare the fertile and precious black soil to oil. Compared with loess, red soil and other types of soil, black soil has the unique advantage of good fertility. However, the irreversibility becomes its deficiency once the soil structure is destroyed. Therefore, how to make rational use of black land without destroying the physical and chemical structure of black soil becomes a tough problem worldwide. The key to black land protection is to balance the relationship between utilization and conservation.

All the four major regions of black land worldwide have experienced four development stages: exploitation, utilization, deterioration, and protection. Some countries have accumulated experience in black land protection. The United States has realized conservation tillage with advanced agricultural tools and fostered world-class agricultural technology giants such as John Deere and Monsanto [1]. With a vast and sparsely populated area and the conditions for crop rotation in a large area, Ukraine achieves black land protection through thorough rest. Argentina, which is currently practicing conservation tillage in black land, comprehensively employs the tillage methods of no-tillage planting, strip planting, straw turnover, and contour planting on a basis of mechanized farming.

Considering the experience of other countries and the context of global food security, China should focus on rational utilization in black land protection. In addition to the basic research on soil and microorganisms, conservation tillage with agricultural machinery and information means should also be conducted for the rational utilization. That is, information and intelligent technologies should be used to evaluate the performance of conservation tillage and further give suggestions for operation. Agricultural information technology has experienced multiple development stages from agricultural expert system, agricultural digitalization/informatization, to agricultural intelligentization based on big data. It has become a core driving force for the development of agricultural productivity and laid a technological foundation for the decision-making in the protective utilization of black land.

1 Black land protection is in urgent need of the support of systematic information system

As early as the 1980s, China learned from the experience of applying digital technology in industrial production and begun to develop agricultural management information system (MIS) for material management in agricultural production [2]. In the early 1990s, the agricultural expert system used computer technology to provide information guidance for

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agricultural production and popularize more advanced agricultural technologies [3]. With the booming of the Internet in the early 21st century, the concept of "Internet + agriculture" developed vigorously, and diverse types of Internet of Things (IoT) and mobile terminal applications facilitated the digitalization of multiple links in agricultural production [4]. With the extensive application of IoT and the emergence of big data in recent years, the artificial intelligence relying on big data is penetrating rapidly to agriculture and greatly promotes the development of agricultural technology.

However, China still lags behind in agricultural information technology, which cannot meet the requirements of protective operation on black land, as manifested in the following three aspects.

(1) The lack of a sound data acquisition system makes it hard to collect the baseline information of black land resources. Considerable research has been carried out for soil information acquisition in China, including sensor technology and satellite remote sensing technology. However, different data acquisition methods can hardly form a system and further comprehensively reflect the black land resources. For example, the data of high-resolution remote sensing satellites cannot comprehensively reflect the evolution of organic matter in black land due to the lack of other data for validation.

(2) The basic models and algorithms are in shortage and cannot support the decision-making in the operation on black land. The core of scientific decision-making in operation is models and algorithms, which, however, are desperately needed in China. The Decision Support System for Agrotechnology Transfer (DSSAT) package developed by the United States has more than 30 years of research and development history and has become one of the main models for simulation experiments in agricultural research worldwide. It is also widely used in agricultural research in China. However, DSSAT is developed on the basis of the climate and soil conditions in the United States and is thus not applicable to China. It only applies to research simulations and is not suitable for practical production [5]. The lack of independent models and algorithms is one of the key reasons for the unclear evolution mechanism of black land and the failure to make decisions for agricultural production in China.

(3) The low intelligence of agricultural machinery caused the lack of machinery for the protective operation on black land. For instance, no-tillage planting is one of the common and important technique in conservative tillage. However, it still has such problems as difficult adjusting of machines and tools, poor performance of full straw mulching, low sowing quality, and slow operation, all of which need to be addressed by the latest intelligent and automation technologies.

To solve the above problems, we need systematic thinking to construct an information system with top-down design to meet the information requirements of black land protection. The data flow in agricultural production involves data collection, state judgment, decision-making, and operation, which is similar to the OODA (observe, orient, decide, act) loop in military operations. In view of such similarity, the Institute of Computing Technology of the Chinese Academy of Sciences put forward the idea of getting data flow through agricultural simulator based on the intelligent OODA loop and piloted it in black land protection.

2 Intelligent OODA loop in agricultural production

The OODA loop, a tool developed by the United States military strategist John Boyd, was used to explain how individuals and organizations can win in an uncertain and chaotic environment [6], also known as the Boyd Cycle. The OODA loop is a description of the air-to-air combat in the tactics and a means to adjust strategies according to the strategic environment of the belligerent. It is an organic model rather than a mechanical model.

In the scenarios where the system operates dynamically, the actuator and the sensor interact with the environment, the dynamic process of which conforms to the OODA loop. ① The application system "observes" the target object through the sensor to collect relevant information. ② The system "orients" the goals and principles of subsequent decision processing according to the application requirements, and prepares the dataset required for decision-making, pre-process the collected data, and performs the preliminary analysis. ③ The system comprehensively analyzes the data and "decides" according to the goals and principles of decision processing, and proposes the optimal control strategy. ④ The actuator (also known as the reactor) interacts with the physical system or the environment, receives the signal and converts it into a physical behavior, and finally "acts" the optimal control strategy and changes the state of the target object, thereby changing the system state. With the state being changed, the system observes the relevant parameters in the new state through the sensor by feedback mechanism and repeats the dynamic cycle of OODA (Figure 1).

The new agricultural production mode based on intelligent OODA loop can be divided into four stages: multidimensional observation, comprehensive orientation, intelligent decision-making, and collaborative action. Intelligent technology is introduced to improve the data acquisition and decision-making precision at the four stages. Under the guidance, standard, and specification of the intelligent agricultural technology system, information is used as the agricultural production factor, and modern information technologies are used for visualized expression, digital design, and information management of the agricultural objects, environment, and farming process. The specific steps are as follows. (1) The information such as "four conditions" (soil moisture, seedlings, insect pests, and disaster) of crop fields, as well as agricultural machinery and

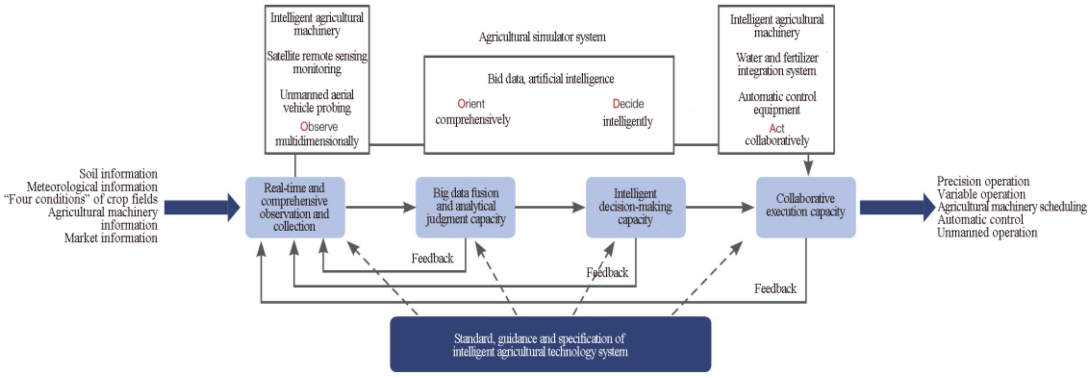

Figure 1 New agricultural production mode based on intelligent OODA loop

even market is comprehensively observed and collected in real time. (2) All the collected data are processed and analyzed uniformly and specific operation commands are obtained based on different agricultural models and algorithms. (3) The intelligent agricultural machinery and automation equipment help to achieve accurate and efficient operation, monitor the changes of the whole system in the processes of information processing, decision-making, and action in real time, and constantly adjust model to achieve the optimal effect.

3 Function and architecture of agricultural simulator

Compared with sciences in major strategic fields, such as atmospheric physics and new materials, the traditional agricultural science experienced the development depending more on experience and simple modeling. The lack of computational modeling directly restricts the modernization of agricultural science. In the era of intelligence, particularly, insufficient data accumulation in agriculture and the lack of computational modeling methods restricts the knowledge mining. Therefore, the first problem to be solved in intelligent agriculture is computational modeling. According to the experience of other disciplines, an effective solution is to develop computable models and simulation systems. However, different from simple scientific discovery activities in such fields as physics and chemistry, research is closely associated with production in agriculture. Thus, it is urgent to construct an agricultural simulator based on new modeling paradigms to achieve an online iterative platform for simulation system and real production system.

3.1 Modeling based on the fifth paradigm

The paradigms for research have been evolving with the advances in technology. There have been four paradigms in modern scientific activities. The first is experimental observation, which is used to discover objective natural phenomena, such as the crystal structure that can be experimentally obtained. The second is theoretical research, in which general laws are summarized by theoretical derivation to form a theoretical system for cognizing and exploring the objective world, such as the First Principles and Newtonian Mechanics. The third is numerical simulation, a method developed with the help of powerful computational tools, such as the generation of high-precision configuration data in a high-performance computer system via the First Principle. The fourth is big data analysis, in which a large number of known data accumulated are calculated to obtain the correlations.

In the above four paradigms, the experimental research and theoretical analysis are separated in practical activities without involving the iterative modeling of the production process. The fifth paradigm couples theoretical research and experimental science into an online iterative whole through "numerical value + data + intelligence" technologies, thus forming an "autopilot system" of the scientific activities involving theory + experiment. The intelligent agricultural simulator is different from the traditional agricultural information systems and the fourth paradigm-based typical agricultural simulation systems [e.g., Decision Support System for Agrotechnology Transfer (DSSAT) and WOrld FOod STudies (WOFOST)], which is manifested in the following two aspects.

(1) Modeling. WOFOST, a model implemented in the European Crop Growth Monitoring System, is mainly applied in the quantitative evaluation of land productivity, area-based yield forecast, risk analysis and interannual yield changes, as well as the quantification of climate change effects. On the basis of the European Crop Growth Monitoring System, DSSAT is developed with consideration to the agricultural characteristics of the United States. It combines the input and output variable formats of various crop growth models and standardized models to facilitate its application and popularization. Both WOFOST and DSSAT are foreign agricultural models and have been widely used. The existing studies of crop models in China use the foreign crop models with or without modification or simplification, and rarely used the self-developed crop models for China. The intelligent

agricultural simulator is the independently developed agricultural software in China, aiming to make China get rid of the restrictions of western countries in agricultural production models.

(2) Function. WOFOST, a universal model for multiple crops, is mainly applicable to photosynthesis, respiration, transpiration, dry matter generation and allocation, crop growth process, root distribution, and soil water regime. The model can simulate the crop growth in three different production processes: potential crop growth, crop growth under water restriction, and crop growth under nutrient restriction. DSSAT is a model for specific crops such as soybean, maize, and sorghum. It, combined with crop-growth models, constitutes the crop system model package which can be further integrated with the public soil water movement model and soil carbon and nitrogen model to simulate the production processes of different crops in different areas. However, both WOFOST and DSSAT have certain shortcomings. ① The outputs are affected by the input data. For example, meteorological data, soil data, and crop data in the test area have large impact on the results. Since it is difficult to collect the data over the years, the missing data at runtime can only be processed as default values, which also impact the output. ② Model application needs to be adjusted according to the actual situations, and the source code needs to be modified. ③ Data are incomplete, such as the lack of meteorological data and spectroscopic data. ④ The neglect of diseases and pests in the model may lead to inaccurate data. The intelligent agricultural simulator decouples the input from the output based on a sound data collection system. It processes the real-time data of agricultural production through edge computing, and completes decision feedback based on scientific guidance, thereby guiding the agricultural production.

Therefore, the intelligent agricultural simulator promotes the mutual effects of scientists' theoretical research and the actual production system through online iteration of the manual simulation system and the actual production system. In this way, it can achieve the online connection of models and algorithms to the command system in production. Thus, the agricultural production can be automated, which will eventually improve operational efficacy and crop yield and reduce production costs.

3.2 Architecture of agricultural simulator

Agricultural simulator can be designed based on the fifth paradigm and used to get data flow through intelligent OODA loop.

(1) Observe: The establishment of a standard system for the data acquisition and storage of agricultural total factors. Agriculture is generally a discipline based on data accumulation and statistical modeling, in which data play a critical role. Therefore, agricultural simulation and decision-making in production must be based on data. A number of basic models such as CERES-Maize and CERES-Wheat in DSSAT and WOFOST are all based on data statistics [7–9]. The online connection property determines that the agricultural simulator must monitor the data in agricultural production online. However, the above models using historical data as system input cannot meet the requirements of agricultural simulator for wide area, large granularity, and real-time online simulation. Therefore, comprehensive data acquisition must be performed on the total factors in the agricultural production via diverse data acquisition techniques such as remote sensing, ground-penetrating radar, and sensor. Meanwhile, the requirement of agricultural simulator for wide area determines that the agricultural data acquisition process is of high concurrency and high throughput. However, the inadequate coverage of public service network in key agricultural areas such as northeast China with the distribution of black land brings challenges to the real-time data acquisition. Thus, agricultural simulator should be designed involving all the processes of data acquisition, storage, and exchange of agricultural production, so as to resolve the data source problem in agricultural simulation.

(2) Orient: The construction of a state evaluation and evolution model of agricultural total factors. The model qualitatively and quantitatively analyzes different factors such as crop health and soil condition, and forecasts their evolution, which is the basis for the decision-making of operation. There have been a number of studies in this respect, such as phenotype identification, stress model, transpiration model, and soil erosion evolution. Nevertheless, these studies still have certain limitations, such as limited data sources and the assumption of homogenous environment changes. For this reason, the models are not universally applicable. Once there is a large deviation between the target environment and the environment where the model is constructed, the models will either be inapplicable or require plenty of time for recalibration. Therefore, it is necessary to automatically modify the existing models or construct new models with big data technology and artificial intelligence technology, so as to achieve the real-time online evaluation of agricultural production in a wide area.

(3) Decide: The development of the decision-making method based on total factors of agricultural production. The decision-making in agricultural production gives corresponding operation decision according to the state of production factors, such as determination of the amount of seeds, pesticides, and fertilizers used, the timing of fertilizer application, the timing of irrigation, and the determination of water consumption. Two core problems need to be solved for agricultural simulator. ① The digitalization of agronomic knowledge system. That is, the basic algorithm and model of agricultural production decision-making is constructed by the existing agronomic knowledge system. ② The modification of algorithms and models based on the production process. That is, a complete data-model loop needs to be constructed to realize the self-evolution of the decision-making algorithm and model. To solve these problems, we need to use the knowledge engineering technologies such as knowledge

graph and knowledge discovery to mine and digitalize agronomic knowledge and employ big data and artificial intelligence to modify models online or construct new models.

(4) Act: The development of the control and execution technology for intelligent operation of agricultural machinery. The last link of the agricultural simulator based on intelligent OODA loop shows the closest association between theory and experiment and is obviously different from that of the models of other paradigms. In agricultural production, the operation scheme made by decision-making includes the high-quality operation via intelligent agricultural machinery and real-time data acquisition by diverse sensors during the operation, forming the OODA loop to achieve the online connection of models and algorithms to the command system in production and thus realize the constant evolution of agricultural simulator. In addition, the automated operation can avoid the poor operation quality of manual operation and reduce the data error of agricultural simulator. To achieve the control and execution of intelligent operation of agricultural machinery, it is necessary to study the precision control of the unmanned equipment system, the electronic system of complete machine and the operation equipment, as well as the collaborative control of the power system and the operation equipment, and other directions, so as to form a complete set of operation equipment required by intelligent OODA loop (Figure 2).

3.3 Software and hardware of agricultural simulator

Considering the above processes, the software and hardware of agricultural simulator should mainly include the following three aspects.

(1) A space-air-ground integrated network for the collection of agricultural production data. The network corresponds to the “observe” link in the intelligent OODA loop. ① On the ground, various sensors and meteorological station devices are used for the acquisition of soil, environmental, and meteorological information. Remote sensing, gamma radiation reception, and unmanned aerial vehicle multi-spectrum/hyper-spectrum are used for the collection of soil, crop, water, and fertilizer information. ② In the air, while the satellite system integrating communication, navigation, and remote sensing is providing data, it can be used to address the problems of wide-area communication coverage for agricultural data backhaul and control command delivery, as well as high precision locating in automatic execution of agricultural machinery. ③ The observation network should have the concurrent access capacity of massive IoT sensors, so that a number of sensors deployed in agricultural production can achieve data backhaul through the IoT network.

(2) Edge computing system. The system is used to provide computing support for “orient” and “act” links. ① The system provides computing support for real-time online orientation of small and medium granularity in agricultural production. For example, diseases and insect pests of crops are generally identified based on close-range images, and such “orientation” models need to be trained by the system on the server. After model training, real-time orientation can be achieved on the edge computing system, so as to reduce the time delay generated by data backhaul to the cloud server and improve the timelines of the decision. ② The system provides basic computing capacity for the control of unmanned driving and machinery operation in the “act” link, thus meeting the requirements of intelligent action of agricultural machinery in this link.

(3) Diversified computing center. The center is a core component or a “brain” of the agricultural simulator, which provides core computing support for the “observe,” “orient,” and “decide” links of the agricultural OODA loop. ① In the “observe” link, the center should support the storage of different types of data, including structured time series data of sensors and meteorological stations, as well as remote sensing data and unmanned aerial vehicle surveying and mapping data, by the object or distributed storage system. At the same time, the access of massive sensors through IoT in the “observe” link also requires the center support. ② In the “orient” link, the center should provide diversified artificial intelligence processing capacity to support the construction of the

Figure 2 Functional diagram of agricultural simulator

state evaluation and evolution model of agricultural total factors. Specifically, it involves the distributed artificial intelligence training aimed at massive remote sensing data, unmanned aerial vehicle surveying and mapping data, gamma radiation atlas data, and far-middle-near infrared data inversion, as well as the model training for multiple users. ③ In the “decide” link, the center should provide support for knowledge engineering, including the large-scale graph computing for knowledge graph. On this basis, the center should provide the reasoning training for agronomic knowledge and decision reasoning, eventually realizing the output of the decision scheme in agricultural production.

4 Application of agricultural simulator in black land protection

To construct the agricultural simulator based on the fifth paradigm, we need to combine the theory, model, and algorithm with agricultural production, and further verify and iterate the theory, model, and algorithm. As one of the regions with high degree of mechanization and early agricultural digitalization and informatization in China, northeast China has various scenarios for the demonstration and pilot of the agricultural simulator. At present, the Chinese Academy of Sciences (CAS) is implementing the Strategic Priority Research Program of science and technology innovation project of black land protection and utilization (black soil granary). The Institute of Computing Technology of the CAS, as the leading organization for the construction of Dahewan demonstration area, builds the black land OODA loop positive feedback system in virtue of the digitalization system and intelligent equipment developed, which overcomes the current agricultural model defects (being isolated, linear and lagged) and forms an agricultural production mode with decision made based on data and acted by intelligent agricultural machinery. Furthermore, system, with smooth flow of data, transforms the agricultural production mode decided based on data and intelligently acted into productivity for black land protection and utilization. The specific effects are mainly reflected in three aspects.

(1) Data observation, a space-air-ground integrated network for multidimensional observation of total factors in black land operation is constructed with various data acquisition technologies such as satellite and unmanned aerial vehicle remote sensing, mobile subaerial sensing devices, and stationary sensor, so as to acquire the local farmland data. Specifically, the data include the basic information of soil (e.g., content of nitrogen, phosphorus, potassium, and trace elements, temperature, humidity, soil moisture, and conductivity), local climate, water (underground water level, salinity, alkalinity, and pH value), biology (crop planting over the years, growth, diseases, and pests), and operation (no-tillage planting, fertilizer and pesticide application precision, and operation speed and area). In the early stage, satellite remote sensing is used for large-scale monitoring of arable land. After the risk area is identified, the unmanned aerial vehicle is used for targeted monitoring of the land. In some important areas, stationary sensors are arranged for long-term continuous observation to realize the agricultural information monitoring of plots. Subsequently, the mobile subaerial sensing device is installed on the intelligent agricultural machinery after it is mature to acquire the soil and crop information during operation, thus improving the monitoring precision.

(2) Data orientation and decision-making. According to the requirements of algorithm analysis, the acquired data are organized, cleaned, and fused to realize the qualitative and quantitative orientation of the acquired data in the subsequent model and algorithm analysis. For black land protection, the spatial distribution of soil erosion in a region is obtained by geographic information system (GIS), and the relationship between different land use types and soil erosion and the impact of slopes on soil erosion are analyzed regarding the local erosion characteristics. According to dynamics of soil erosion, land use, and vegetation coverage, we can construct a transition matrix for erosion and environmental factors and analyze their correlations, so as to predict the dynamics of soil erosion in real time. For black land operation, the digital expression and modified model for the relationship of basic information (such as soil elements, water, fertilizer, temperature, humidity, light, diseases, pests, and weeds) with crop growth trend, disaster warning, and yield estimation are constructed for specific crops by statistical learning, artificial intelligence, and optimization of complex systems. Finally, real-time suggestions are given for the water, fertilizer, pesticide, agronomy and other aspects of specific crops at different stages through systematic machine learning and simulation.

(3) Action. On the one hand, the existing agricultural machinery is intelligently transformed and upgraded. On the other hand, breakthroughs are made in the control chip, operating system, unmanned driving, and precision control of the new-generation clean-energy intelligent agricultural machinery. Furthermore, series (50–400 Hp) of complete clean-energy intelligent agricultural machinery for main crops on black land are developed with motor, battery, electronic control, CNC chassis, and other technologies. In addition, for key links of conservation operations such as no-tillage planting, straw returning to the field, and strip planting, efforts should be made to combine agricultural machinery and agronomy and enhance the integrated application of sensors and intelligent agricultural machinery for variable operation. The intelligent agricultural machinery with intelligent network, unmanned driving capacity, and independent decision-making capacity can not only complete the precise and efficient conservation operation in the full life cycle of tillage, planting, sowing, management, and harvesting of specific crops according to the operation command, but also collect soil and crop information as well as

operation quality information (deep tillage and deep scarification, precision sowing, and variable fertilizer and pesticide application) in real time. It can then carry out the iterative optimization in automatic assignment of tasks, intelligent scheduling of agricultural machinery, guidance on the quality of agricultural machinery operation and other aspects through intelligent OODA loop.

5 Challenges and countermeasures

The progress of science and technology has provided new means for agricultural production. The utilization and conservation of black land need modern information technologies. The intelligent OODA loop serves a new research method for the construction of a agricultural simulator for total factors and provides a new idea for black land protection. However, the construction of agricultural simulator is the engineering based on information technology and involves multiple disciplines. Special attention should be paid to the modeling of formation, destruction, protection, and farming of black land in information space. To apply the black land protection mode led by information technology in the black soil granary project supported by the Strategic Priority Research Program of CAS, we suggest to strengthen the work in the following three aspects.

(1) Interdisciplinary collaboration. To give full play to the role of agricultural simulator in black land protection, we need to model the existing conservation tillage technologies, and such elements as soil, microbes and environment in information space, and collect massive real-time data for the iterative training of the model in information space. At present, different research teams for black land protection focus on their respective fields and develop their respective conservation models. However, these models are still based on traditional research paradigms. In the follow-up studies, these teams need to strengthen their cooperation to realize the integration of information with agronomy, soil science, and biology, thus forming a complete agricultural model.

(2) Data mining for black land protection. A large amount of funds is required for the collection of data flow. However, since the input and output of agricultural production are lower than those of the secondary and tertiary sectors, the data value may not be reflected, which thus restricts the supply of funds for information construction. Despite the efforts to increase the investment in agricultural information construction and certain achievements made in recent years, it is not a very secure way to always rely on the national investment. Therefore, we need to carry out commercial operations in the future to realize the data value in the rapid data flow and better input it into the iteration of intelligent OODA loop.

(3) Development of scientific devices for black land protection. New research paradigms, technologies, and research devices are effective tools to accelerate the output of research results. For black land protection, we need to build a research and development platform for the agricultural simulator of total factors, and then digitalize the traditional conservation models based on the platform and train these models to make them approximate the practical agricultural production. To achieve this goal, we need to take the agricultural simulator as a scientific device for black land protection, and use it to provide an "examination report" for the implementation of measures in black land protection.

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